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1216507

DRAWINGS ATTACHED

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(71) We, CAPVAC INDUSTRIES, INC., a corporation duly organized and existing under the laws of the State of Texas, United States of America, of 417 South Gulf Boulevard, Freeport, State of Texas, United States of America, do hereby declare the invention for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention pertains generally to bulk material moving apparatus and particularly to apparatus adapted for moving bulk material, such as hygroscopic material, which heretofore has not been movable in large volumes in a rapid manner. The present invention is adaptable particularly to moving bulk materials, through a wide range of sizes and shapes such as lump coal, gravel, finely ground cake fluor, cereals, and light fluffy talc.

Reference is made to Application No. 57373/67, Serial No. 1,216,506, which describes and claims a bulk material moving apparatus and out of which the present application has been divided.

While various means have been employed to move dry materials by conveyor, no known funnel or other device has been capable of providing a fail safe, non-clogging, escape method for dry products to flow through metering means, without requiring bin vibrators and shakers to prevent the various materials from bridging, rat holing, clinging, or packing. The present invention is adaptable for use in a plurality of conveying functions which will be set forth in the following description.

The present invention is adapted for providing a satisfactory solution to the problems which have heretofore been encountered in the attempted movement of various types of material including material having hgyroscopic properties.

Thus it is an object of the present invention to provide an escape means for materials whose structure heretofore required shakers or vibrators to provide a substantially constant velocity to the product being moved.

Still another object of the present invention is to provide by gravitational force the required energy level to cause material to flow evenly without restriction due to mass, friction coefficient, cohesive attraction and molecular structure of such material.

A still further object of the present invention is to provide a means to insure a material to flow with a near top level attitude, thus allowing measuring instruments to obtain accurate data heretofore accomplished by weight controls or inaccurate readings which were the result of the inverted repose angle of the dry product material whose repose angle would constantly vary in accordance with its ever changing moisture content.

Still another object of the present invention is to provide an unrestricted passage of any dry material whose cohesive attraction and surface tension does not exceed the force of gravity.

Still another object of the present invention is to provide a constant flow of any material having a force of adhesion to metal lower than the force due to the weight of such material. For example, grain and other animal feed products containing molasses and other sticky substances will flow without restriction when their adhesive characteristics fall within the mentioned limits.

Yet another object of the present invention is to provide a structure adaptable for use on various configurations, sizes and types of material collecting and discharging devices whose characteristics require a constant flow without restriction, are closely coupled and require low profile, while utilizing a gravitational discharge method.

According to the invention there is provided a material transfer vessel comprising a con-

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tainer having a bottom closed by a valve means through which material can be removed from the container, an inlet for dry particulate material positioned within the container and opening downwardly in a direction facing the bottom of the container but spaced a substantial distance above the bottom so that said material may flow into the container and build up on the bottom, whereby additional material flowing into the container impinges on that which has been built up on the bottom, an air outlet in an upper portion of the container above the opening of the inlet, a vacuum source connected to said air outlet, said air outlet having a cross-sectional area substantially greater than the cross-sectional area of the material inlet but substantially less than the cross-sectional area of the container, such that the velocity of air through the outlet is substantially less than the velocity of material through the inlet, whereby a relatively small proportion of said material is carried out through the outlet.

Such a vessel preferably has the first and second surfaces originating on substantially the same horizontal plane, as, for example, when the vessel forms the lower portion of a container for the bulk material. Furthermore, in the preferred form of the invention the first and second surfaces originate equidistantly from a vertical plane disposed intermediate these surfaces, whereas at substantially all other horizontal planes between the inlet and the outlet the distance from the first surface to the vertical plane is different from the distance from the second surface to the vertical plane. Thus the axis of the vessel, constituting the locus of centroids of horizontal sections from the inlet to the outlet of the vessel is not a straight vertical line, but instead is a curved line.

In the drawings,

FIGURE 1 is a combined side elevational view of the vessel and circuit schematic of the control system of the present invention;

FIGURE 2 is a combined funnel shape and chart having curves incorporated in the vessel of the present invention plotted on X and Y axes;

FIGURE 3 is a cross-sectional top view of a portion of the curves incorporated in the vessel of the present invention taken along line 3—3 of FIGURE 2;

FIGURE 4 is a sectional elevational view of the material mover mechanism of the present invention utilized with a vacuum pump, and

FIGURE 5 is a sectional elevational view of the material mover mechanism of the present invention utilized with a pressure source.

Briefly stated, the present invention includes means for providing unrestricted uniform feed characteristics to bulk products whose physical nature has heretofore not been adaptable to existing apparatus. It will be appreciated that the principles involved in the present invention may be utilized in many shapes and dimensions, and that the shape shown and described may be altered in lines of space and configuration.

Referring now to the drawings in detail, FIGURE 1 is a combined side view of a vessel and a schematic of the control system of a form of system for utilizing the present invention. Vessel means 10 includes an upper semi-spherical portion 134. An inlet 52 is utilized for bringing material into the chamber of vessel means 10.

The vessel means 10 provides a lower material collecting and metering system chamber, and a hopper which is connected to the inner chamber walls at the top section of vessel means 10 thereby providing the vessel of the present invention with complete access to all materials which pass into the top inner chamber. The lower opening of the hopper can be connected to a metering valve or rotating discharge valve well known in the art.

The equipment here described including the hopper is fully portable and may be mounted on a truck, trailer or skid.

Vessel means 10 has coupled to the upper semi-spherical portion 134 an inlet 52 for material which is fed to the vessel means. A pressure relief valve 154 is coupled to the semi-spherical portion 134 as is a pressure discharge valve 156. The pressure relief valve 154 may be spring loaded and allows the vessel means 10 automatically to vent to the atmosphere. The pressure discharge valve 156 vents to the atmosphere and is coupled through lead 157 to a timer housed in control panel 12. Pressure discharge valve 156 also may be manually operable. An electric motor indicating device 280 is utilized for indicating the upper level of material positioned in vessel means 10. The electrical motor device 280 is coupled through lead 300 to the control panel 12.

A lower level electric motor device 290 is positioned on vessel means 10 and coupled through lead 302 to control panel 12.

Solenoid 312 is coupled to the vessel means 10 and through lead 314 to the control panel 12.

Air valve 270 and operating solenoid 271 are coupled to the vessel means 10 and through lead 316 to the control panel 12.

Valve 268 and operating solenoid 269 are coupled through lead 318 to the control panel 12.

Vacuum-pressure means 320 is coupled through conduit connecting line 322 to valve 270. It will be appreciated that such vacuum-pressure means may be either a vacuum pump or a pressure device such as a compressor. As will be explained subsequently, the vacuum-pressure means depends on how the equip-

ment will be used. In one application both vacuum and pressure is provided alternately and continuously.

Generally material enters the vessel means 10 through inlet 52 and is discharged through valve 268 at the lower portion of the vessel means 10. The control panel 12 provides indication and selected actuation of the valves as will be explained in greater detail subsequently. The control panel provides selective control of the components of the present invention and may vary in construction according to the requirements of a particular job. It will be appreciated that the material inlet 52 may be coupled to suitable means such as hose which will allow material to be picked up and fed to the vessel means 10.

The valve 268 may be a solenoid actuated valve or a star valve which allows continuous flow of material through the vessel means 10.

FIGURE 2 is a simplified representation of the curved surfaces in cross-section, forming a vessel, and the interior of cylindrical portion of the vessel means of the present invention set forth along X and Y coordinates. The curved surfaces may be generally hyperbolic in vertical section and opposing surfaces have different curvatures as distinguished from the hoppers shown in U.S. Patent No. 3,071,297 to Lee, where identical hyperbolic curves are used on opposed sides. Furthermore, different coordinates may be used for each hyperbola.

The said vessel may be formed by two such opposed curved surfaces between parallel or converging back and front surfaces, or by two pairs of such opposed curved surfaces, or the vessel may have any other suitable horizontal cross section.

In the embodiment shown in FIGURE 2 the X coordinate is horizontal and has been positioned at the juncture point 50 and 51 of the cylinder wall 38. The Y coordinate has been positioned at the midway point of the diameter of the cylinder formed by wall 38 so that Y is substantially in the center of the cylinder formed by wall 38.

The curve designated as A in the accompanying table for curve A is the same as surface 40 while curve B in the accompanying table for curve B represents curved surface 41. Thus, in the tabulation for curve A, since curve A lies in area III all values of X and Y are negative. It will be appreciated in reviewing the tabulation for curve A and Y' (prime) is 0 for the first four readings of X in the right hand portion of the table for curve A. As the value of X is 4 in the right hand portion for the table for curve A, Y is 8 and Y' (prime) is 18. Y' (prime) is the extension of Y to indicate that there is an intercept or dual value of Y when plotting the curve A. As shown in the lower portion of the table for curve A, X is positive for areas I and IV and negative for areas II and III while Y is positive in areas I and II and negative for areas III and IV. The curv A is not identical or even substantially the same as curve B as will be explained subsequently.

Curve B which is the curve portion 41 is tabulated in the table for curve B and it might be noted that all values for X are positive while all Y values are negative. The lower portion of the table for curve B indicates the areas where X and Y are positive and are negative.

It will be appreciated, therefore, that curve A and curve B are not identical. The equations for curve A and curve B are not set forth with great accuracy although the tables for curve A and the tables for curve B have proven to be satisfactory in practicing the present invention. The structure of the present invention allows various types of material to be readily moved over the curved surfaces 40 and 41 without build-up at any point on the curved surfaces.

As is well known in the bulk material art, the angle of repose of bulk material is the angle, less than ninety degrees, which the slope of bulk material forms with respect to a horizontal plane. In moving bulk material through a conventional funnel the funnel is designed with a slope such that it is a configuration substantially the same as the inverted triangle formed by the two slopes dedetermined by the angle of repose of the bulk material to be handled in the funnel. The present invention provides two dissimilar, irregularly shaped members which act to provide a varying angle X where X=180 degrees minus (the angle of repose times two).

Referring again to FIGURE 2 it will be seen that the weight of material is greater on curve B than on curve A in relation to the Y axis. Thus, more compression is forced on the material along surface 41 while the lower portion of surface 40 has less compressive force than at any other portion of the surfaces 40 and 41. The angle of the upper portion of surface 40 is determined by the friction between the bulk material and the surface, and by the repose angle of the material moving transverse to the Y axis. It will be appreciated that the Y axis is not equidistant from points 43 and 45. Furthermore, at any horizontal plane except at the X axis and the Y axis is not equidistant from the two curves. Thus the axis of the vessel, as determined by the locus of centroids of cross-sections taken at various horizontal planes from the inlet to the outlet, is not a vertical straight line, but is a curved line. Therefore, the primary object of moving heretofore difficult-to-move-material may be achieved rapidly and effectively because the lower part of the material is moved by breaking the center flow of the material.

FIGURE 3 is a cross-sectional top view

taken along line 3—3 of FIGURE 2 to show variations of the curved surfaces. Curved surfaces 40 and 41 are shown coupled to planar members 60 and 62. Points 50 and 51 are shown in Figure 3 in broken lines to indicate that surfaces such as 64 and 66 might be utilized if the curved portions 40 and 42 are extended to points 50 and 51. Also, surfaces 68 and 70 might be utilized with the curved portions 40 and 41. The broken lines shown in FIGURE 3 merely are attempts to indicate that the planar surfaces such as surfaces 60 and 62 actually utilized and shown in FIGURES 1 and 2 are not necessary but may be curved i.e. of any suitable configuration such as that indicated by surfaces 64 and 66 or by surfaces 68 and 70. Ease of construction apparently would dictate that surfaces 60 and 62 be planar rather than curved as shown in the broken lines of curves 64 and 66 and curves 68 and 70.

FIGURE 4 is a sectional elevational view of the vessel means of the present invention when vacuum is provided to such vessel means from a vacuum pump (not shown). Vessel means 10 has positioned thereon an inlet pipe 52 the lower end of which constitutes an inlet for material or product to be brought into the chamber 186 when plunger 256 is opened. Plunger 256 is operated by air cylinder 178 which is coupled to a valve (not shown) operated by solenoid 312. As explained previously pressure relief valve 154 is coupled to the upper semi-spherical chamber 134 and allows venting to the atmosphere of upper outer chamber 144. A discharge line containing a valve 156 also is positioned on semi-spherical portion 134 and allows chamber 144 to be vented to atmosphere when the valve 156 is manually operated. Electric motor device 280 is coupled through stem 182 to a rotating level control paddle 184 in a manner well known in the art. The level control paddle 184 along with the electrical device 280 provides a signal for operating the air cylinder 178 of plunger 256.

Inner suction header 160 extends circumferentially to allow attachment of filters such as filter 146 and 148. Filters 146 and 148 may be constructed of perforated pipe having sock covers to filter the dust-laden air.

Inner top chamber opening 162 provides an air outlet and allows communication from the product collector chamber 186 to the top outer chamber 144 thereby providing inner space dust velocity reduction within the vessel means 10. A vertical separator baffle 172 has a fixed centripetal separator ledge 170 for air control to allow the proper movement of material.

Wall 38 defines the inner product collecting chamber 186. Such chamber 186 has a semi-spherical upper portion and a cylindrical lower portion and converges downwardly to the outlet 42. Surfaces 40 and 41 provide the downward opening and the configuration of surface 40 and 41 has been explained in detail previously in conjunction with FIGURES 2 and 3.

Disposed below the filters 146 and 148 is an inner filter storage area 150 and an inner filter storage area 152.

A rotating paddle 284 is disposeed on stem 282 and coupled to electric motor control 290. The paddle 284 and the electrical device 290 provide a signal for actuation of air cylinder 178 in a manner similar to that described in connection with upper paddle 184 and electric control 280.

A dust door 198 is positioned in surface 40 to allow dust collected in the inner filter storage area 150 to be passed out of outlet 42 when dust door 198 is retracted by actuation of the control stem 192. Similarly a dust door 202 is positioned in surface 41 to allow dust which has been accumulated in dust collection area 152 to be discharged downwardly through outlet 42 upon actuation of stem 196.

The vessel means 10 may be positioned on a suitable frame 292 with rivets or bolts such as 294 and 296.

A star valve 266 may be positioned within housing 268 to allow communication of outlet 42 with a pressurized material collecting pan 234 coupled to outlet line 16. Air inlet line 22 is in communication with product collecting pan 234 and outlet 16. The star valve 266 may be of any type well known in the material handling art. Such valve is a rotating bulk product material feeder valve for measuring the product discharge and for supplying an air lock from product collecting pan 234.

The vessel means 10 shown in FIGURE 4 is utilized with vacuum pump coupled to valve 270 which has solenoid 271 coupled thereto for operation of the valve. Valve 270 is coupled to elbow 158 which is in communication with the inner suction header 160. Valve 270 is a multiport valve which may for example be a Rockwell-Nordstrom Valve arrangement No. 1—three way, two port, 90 degree turn, two position valve. Valve 270 is operated by air cylinder having a two position stroke. The air cylinder of valve 270 is actuated by an air electric solenoid valve. In position No. 1 wherein vacuum is utilized, air cylinder unit 178 opens and valve 270 opens to the vacuum pump by the solenoid signal. This exhausts air to permit entry of material. In position No. 2 during the pressure cycle the air cylinder 178 closes and valve 270 closes to vacuum supply but opens to pressure. Thus the material is forced out of hopper 36 under pressure. The return to vacuum is controlled by a timer device which opens vessel pressure discharge valve 156 to atmosphere to release the pressure which has built up in the vessel. When the pressure within the vessel has been vented t atm sphere

through the vessel pressure discharge valve 156, another signal is transmitted to the solenoid operating valve 270 and to the solenoid operating air cylinder 178. Thus it will be apparent from the above explanation that the sequence of operation of the vessel means 10 when a star valve 266 is utilized will be such that the movement of material through the outlet 42 will be in discontinuous batches. As explained previously FIGURE 4 shows the vessel means of the present invention adapted for use with a vacuum pump (not shown) which may be coupled to the valve 270 in a manner well known to those skilled in the vessel art in the material moving art. While operating with a vacuum pump as shown in FIGURE 4, the upper electrical control unit 280 will cut off the vacuum pump in the event that too much material is stored in the chamber 186. The lower electrical control unit 290 will actuate the vacuum pump when the material in chamber 186 falls below the level of paddle 284.

Referring again to FIGURES 2 and 3, it will be apparent from the configuration of surfaces 40 and 41 that material which is being brought into the inner product collecting chamber 186 is positioned along members 40 and 41. The configuration of these members is such that the material flow downwardly through outlet 42 is continuous and may allow many different kinds of material to be effectively discharged from the vessel and move through the outlet 16. The configuration of members 40 and 41 prevents rat holing or material accumulation along such members even though the material which is being moved may possess "sticky" characteristics which have heretofore prohibited or limited mass movement thereof.

Thus it will be apparent from the foregoing explanation of Figure 4 that FIGURE 4 represents on embodiment of the present invention with valve 270 positioned for coupling to a vacuum pump. The star valve 266 provides continuous flow of material which is brought in through inlet 52 from outlet 42.

FIGURE 5 is a cross-sectional elevational view of the vessel means 10 utilized with a pressure source coupled to valve 270 after valve 270 is rotated 90 degrees. The valve utilized with the embodiment shown in FIGURE 5 may be a full bore pattern two-way, hard surface valve which may be manually operated or operated by an air cylinder. Member 269 opens and closes the outlet 42 with respect to the product collecting pan 234.

Thus it will be apparent in reviewing FIGURE 5 that when pressure is utilized on the vessel means 10 through valve 270, that the air cylinder 178 operates rubber plunger 256 to periodically open and close inlet 52 to discharge material which has been accumulated within chamber 186 through operation of the level indicator devices having paddles 184 and 284. For example, member 269 will be closed during a filling cycle while the air cylinder 178 provides downward movement of plunger 256 to allow material to be brought in through inlet 52 to the product accumulation chamber 186 while vacuum is provided. As material accumulates within the chamber 186 and as the paddle on the upper level indicator is actuated, plunger 256 is actuated by the air cylinder 178 to close the inlet 52 and the member 269 is opened to allow discharge of the material which has been accumulated in chamber 186. At this moment pressure is applied to the chamber 186 through valve 270 which was actuated by upper level controller 280 to discharge the material in chamber 186 past valve 269.

Paddle 284 actuates a timer device in the control panel 12 and a signal is provided to open the upper discharge valve 156 to release pressure within vessel means 10 dropping the pressure within vessel means 10 to atmospheric pressure after a brief interval of time, which may be on the order of several seconds, the timer device provides a pneumatic signal to close valve 269 and 156, and actuates air cylinder 178 to open plunger 256 and allows valve 290 to be coupled to a vacuum pump. Vacuum is provided to the vessel means 10 until the above action is repeated. The operation of the vessel means 10 as shown in FIGURE 5 includes a pressure source such as an air compressor and a vacuum source such as a vacuum pump. The pressure and vacuum act together on an alternate basis to move material in the vessel means 10.

As explained previously in conjunction with FIGURE 4 the vessel means 10 allows movement of heretofore unmovable material or material which has been difficult to move without the problems previously encountered. The operation of the vessel means 10 is achieved through coordinated operation of member 269, plunger 256 and pressure relief valve 156.

By employing the vessel of the present invention it is possible to move hygroscopic materials such as fertilizer in bulk at very high quantity thus economically allowing loading and unloading of ships, barges, railroad cars, and other storage facilities.

It will be appreciated that the present invention will serve a dual function by being available to unload material from ships, barges, railroad cars, bulk storage systems and convey such material to other suitable storage means, or to measure, weigh and convey by metered volumes said material to any point for use in blending or manufacturing other products.

Through pneumatic conveying at high pressure of abrasive materials it is possible to convey these abrasive materials whose characteristics are hygroscopic or other materials that contain a high moisture saturation that have been in the past very difficult to convey.

FOR CURVE A

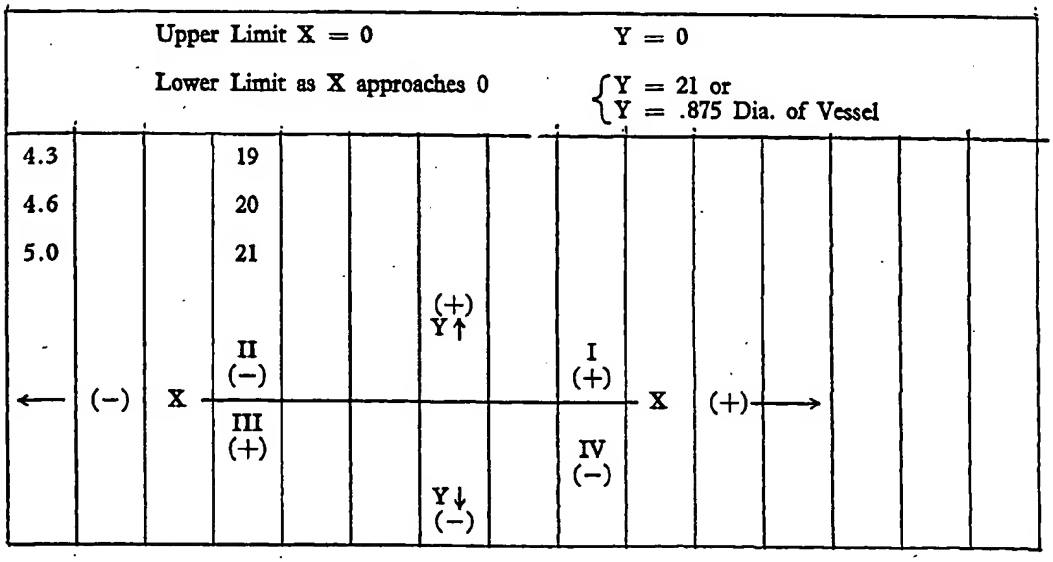
Upper Limit X = 0 Y = 0

Lower Limit as X approaches 0 $\begin{cases} Y = 21 \text{ or} \\ Y = .875 \text{ Dia. of Vessel} \end{cases}$

Note: All values of X & Y are negative

X	Y	X	Y	Y
12	0	0	21	0
9	1	1	21	0
7.8	2	2	21	0
6.9	3	3	21	0
6.0	4	4	8	18
5.3	5	5	5.4	
4.8	6	6	3.8	
4.4	7	7	2.6	
4.0	8	8	1.7	
3.7	9	9	1.0	
3.5	10	10	0.5	
3.4	11	11	0.2	
3.3	12	12	0	
3.4	13			
3.5	14			
3.6	15			
3.7	16			
3.9	17			
4.0	18			

FOR CURVE A Continued



FOR CURVE "B"

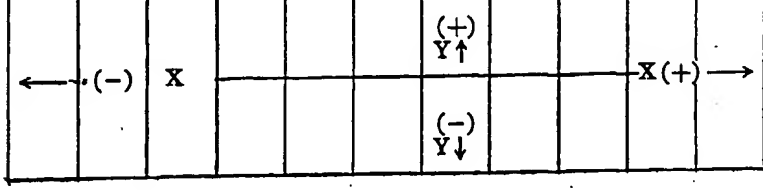
Upper Limit X = 0 Y = 0

Lower Limit X = .7 Y = 21

Note X Values Are all Positive

Y Values Are all Negative

X	Y	X	Y
12	0	0	21
10.3	1	1	20
9.2	2	2	16.5
8.3	3	3	13
7.5	4	4	10.5
6.8	5	5	8.2
6.2	6	6	7.0
5.6	7	7	4.8
5.0	8	8	3.5
4.6	9	9	2.2
4.2	10	10	1.4
3.7	11	11	0.4
3.4	12	12	0
3.0	13		
2.6	14		
2.3	15		
2.0	16		
1.7	17		
1.4	18		
1.2	19		
0.9	20		
0.5	21		



WHAT WE CLAIM IS:—

1. A material transfer vessel comprising a container having a bottom closed by a valve means through which material can be removed from the container, an inlet for dry particulate material positioned within the container and opening downwardly in a direction facing the bottom of the container but spaced a substantial distance above the bottom so that said material may flow into the container and build up on the bottom, whereby additional material flowing into the container impinges on that which has been built up on the bottom, an air outlet in an upper portion of the container above the opening of the inlet, a vacuum source connected to said air outlet, said air outlet having a cross-sectional area substantially greater than the cross-sectional area of the material inlet but substantially less than the cross-sectional area of the container, such that the velocity of air through the outlet is substantially less than the velocity of material through the inlet, whereby a relatively small proportion of said material is carried out through the outlet.

2. A material transfer vessel as defined by claim 1, wherein said air outlet comprises an opening substantially centrally disposed in the top of said container.

3. A material transfer vessel as defined by either of claims 1 and 2, and including a baffle between said material inlet and said opening.

4. A material transfer vessel as defined by claim 3, wherein said material inlet extends downwardly into said container, and said baffle extends downwardly from the top of said container to below the opening of the material inlet.

5. A material transfer vessel as defined by any of claims 1 to 4 wherein said container comprises an outer pressure shell having an upper closed end and a smaller inner shell disposed in said outer shell with an annular space therebetween and a space between the upper end of the inner shell and the upper end of the outer shell.

6. A material transfer vessel as defined by claim 5, and including filter means in said annular space intermediate said vacuum source and said air outlet.

7. A material transfer vessel as defined by claim 6, and including a door in the wall of the inner vessel below said filter means, and means for transferring filtered material from said annular space through said door and into the inner vessel.

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1216507 COMPLETE SPECIFICATION
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Sheet 1

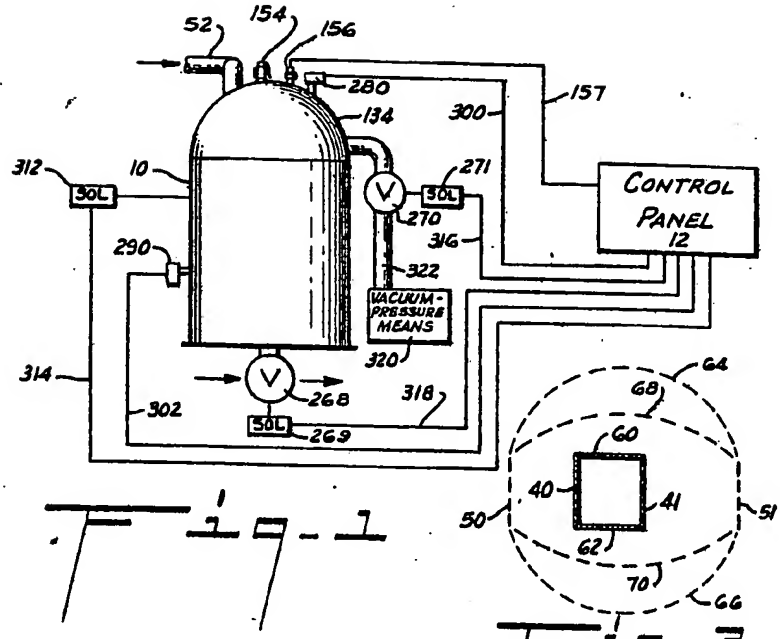

Fig. 1

Fig. 3

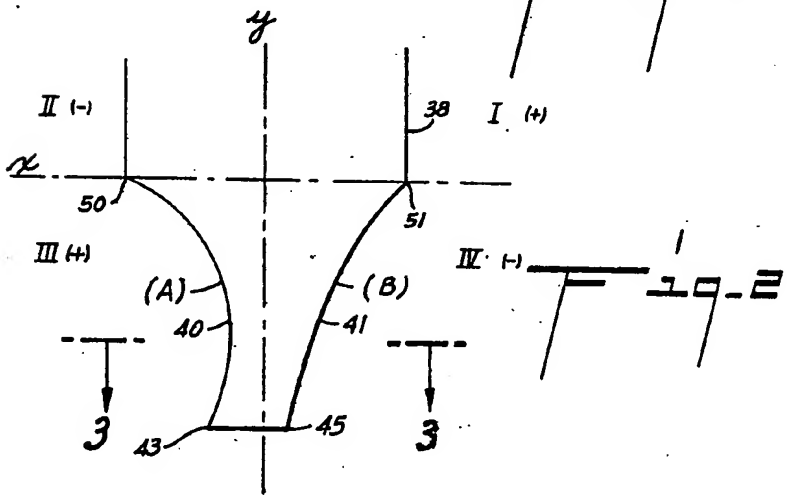

Fig. 2

1216507 COMPLETE SPECIFICATION
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Sheet 2

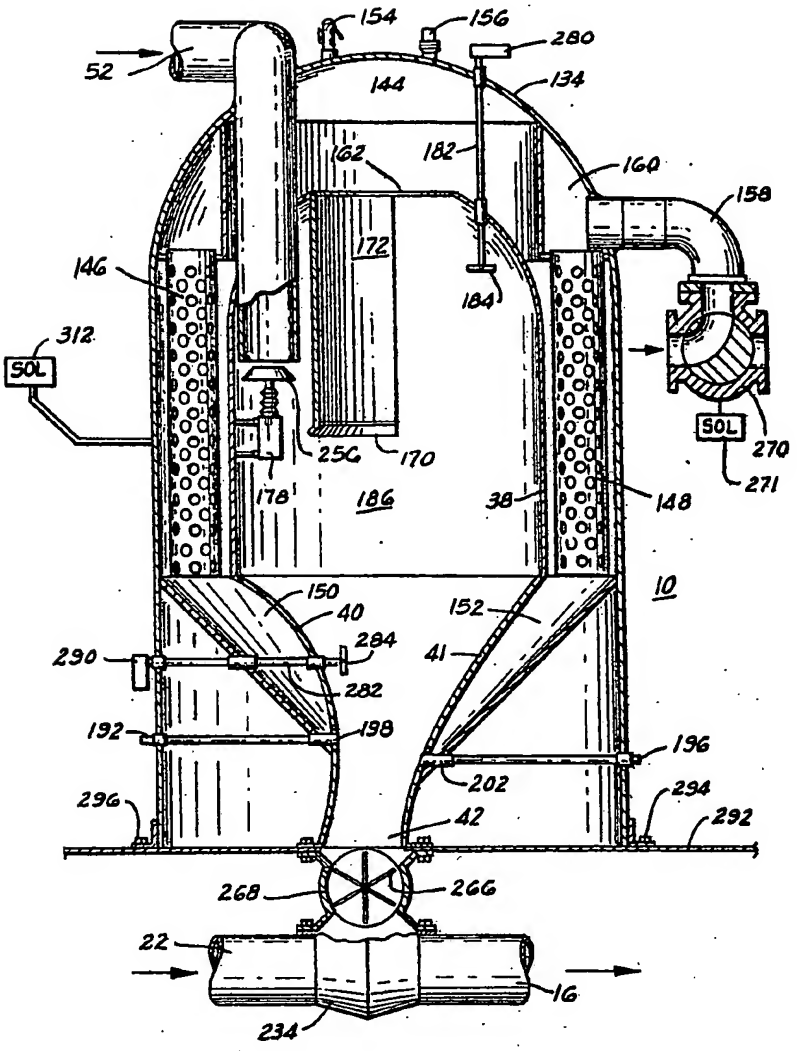

FIG. 4

1216507 COMPLETE SPECIFICATION
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Sheet 3

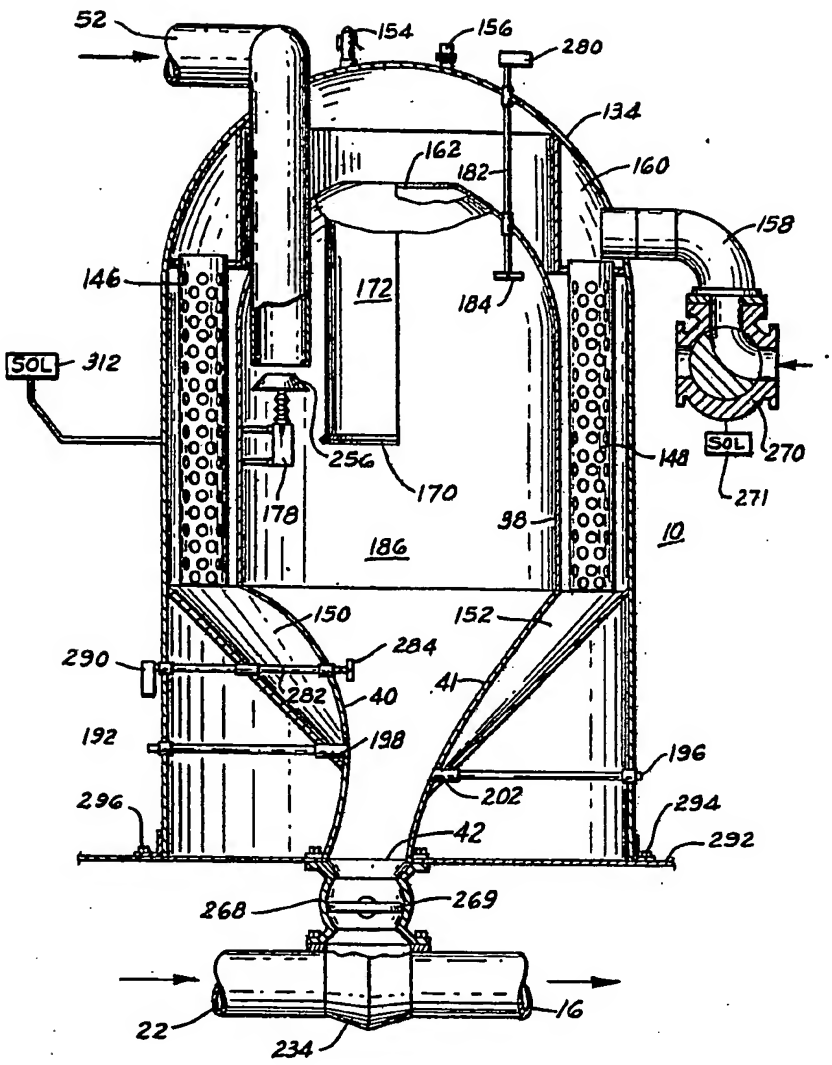

Fig. 5